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by

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ABSTRACT

Positron and negatron spectra of Cu^{64} have been investigated in the Columbia solenoid β -ray spectrometer. By using thinner and more uniform sources and employing a more rigorous Coulomb correction factor, the deviations at the low energy region were greatly reduced as compared with previous work reported from other laboratories. It seems probable that the remaining small observed deviation is instrumental and the Cu^{64} spectra are actually of the allowed type.

* * * * *

Radioactive Cu decays either by positron- or negatron-emission to Ni or Zn with a half-life of 12.8 hours. In 1945 Backus¹ reported disagreement between the observed ratio of the number of positrons to the number of electrons in the region below 50 Kev as compared to that predicted by the Fermi theory of beta-disintegration. Recently, Cook and Langer² investigated both the positron and negatron spectra from Cu^{64} over the entire energy region and found that both negatrons and positrons at low energies are too numerous to be accounted for by theory. Since the technical difficulties involved in the study of the beta-ray spectrum at very low energy are considerable, it is desirable to know how far the remaining discrepancies between experiment and theory at low energy can be reduced by improving experimental technique and employing a more rigorous Coulomb correction factor in interpreting the data.

The Columbia University solenoid β -ray spectrometer^{3,4} was used in this investigation. In order to distinguish between electrons and positrons, a simple modified baffle system has been used and is found to transmit particles of one sign only, introducing no detectable scattering. The axis of the spectrometer is at least six feet away from any walls and is orientated along the earth's magnetic meridian. The vertical component of the earth's magnetic field is compensated by means of a pair of Thomson coils.

The radioactive Cu^{64} was prepared by intense deuteron bombardment of copper in the Columbia cyclotron. In carrying out the chemical purification and preparation, precautions for yielding high specific activity were particularly stressed. In the first few preliminary runs, the source was

prepared by direct deposition of a drop of CuSO_4 solution on a collodion film. The deposit tends to crystallize at the edge of the drop, and therefore, forms a non-uniform source.

A more uniform source can be obtained by adding a trace of detergent to the CuSO_4 solution or from a colloidal suspension of $\text{Cu}(\text{OH})_2$. The source backings used throughout this investigation were thin collodion film of about $4\mu\text{g}/\text{cm}^2$. The counter window consisted of 5 or 6 layers of collodion film of $3\text{--}4\mu\text{g}/\text{cm}^2$ each. Auxiliary experiments showed that this counter window should have negligible effects on the electron distribution above 20 Kev.

Several runs with sources varying from $0.3\text{ mg}/\text{cm}^2$ to $\sim 0.1\text{ mg}/\text{cm}^2$ showed a gradual but consistent reduction of deviation versus the source thickness at low energy region. Therefore, the importance of preparing extremely thin and uniform sources can never be over-emphasized. With the thinnest source ($\sim 0.1\text{ mg}/\text{cm}^2$) prepared with the present facilities, the deviation was found to be much less than previously reported.

In comparing the experimental data with the Fermi theory, the Coulomb correction factor has been reexamined and modified. Longmire and Brown⁵ recently calculated the screening effect due to atomic electrons and the relativistic effect (which has often been neglected for $Z < 29$) for Cu^{64} electrons and positrons. These corrections are considerable for electrons of energies below 200 Kev and for positrons of energies below 100 Kev (Figure 1). Applying these corrections, the observed electron distribution (Figure 1) agrees with the theory from upper energy limit down to ~ 70 Kev. At least part of the remaining discrepancy could very well be due to the finite thickness of the source. The deviation in the case of positron appears to start at a much higher energy ~ 200 Kev (Figure 1). If these deviations are due to the scattering of electrons or positrons into the low energy region, the effect would be much more pronounced in the case of positrons because there are so few positrons at low energies. This can better be illustrated by comparing the area under the momentum distribution curves (Figure 2) where the difference between the experimental and theoretical distribution for both positrons and electrons is about 1 to 2% of the total emission, while the previous work reported an excess of 9% for positrons and 6% for electrons.

In view of the large decrease in the deviation resulting from the use of thinner and more uniform sources and the use of a more rigorous Coulomb correction factor, it seems probable that the remaining small observed deviation is instrumental and the Cu^{64} spectra are actually of the allowed type.

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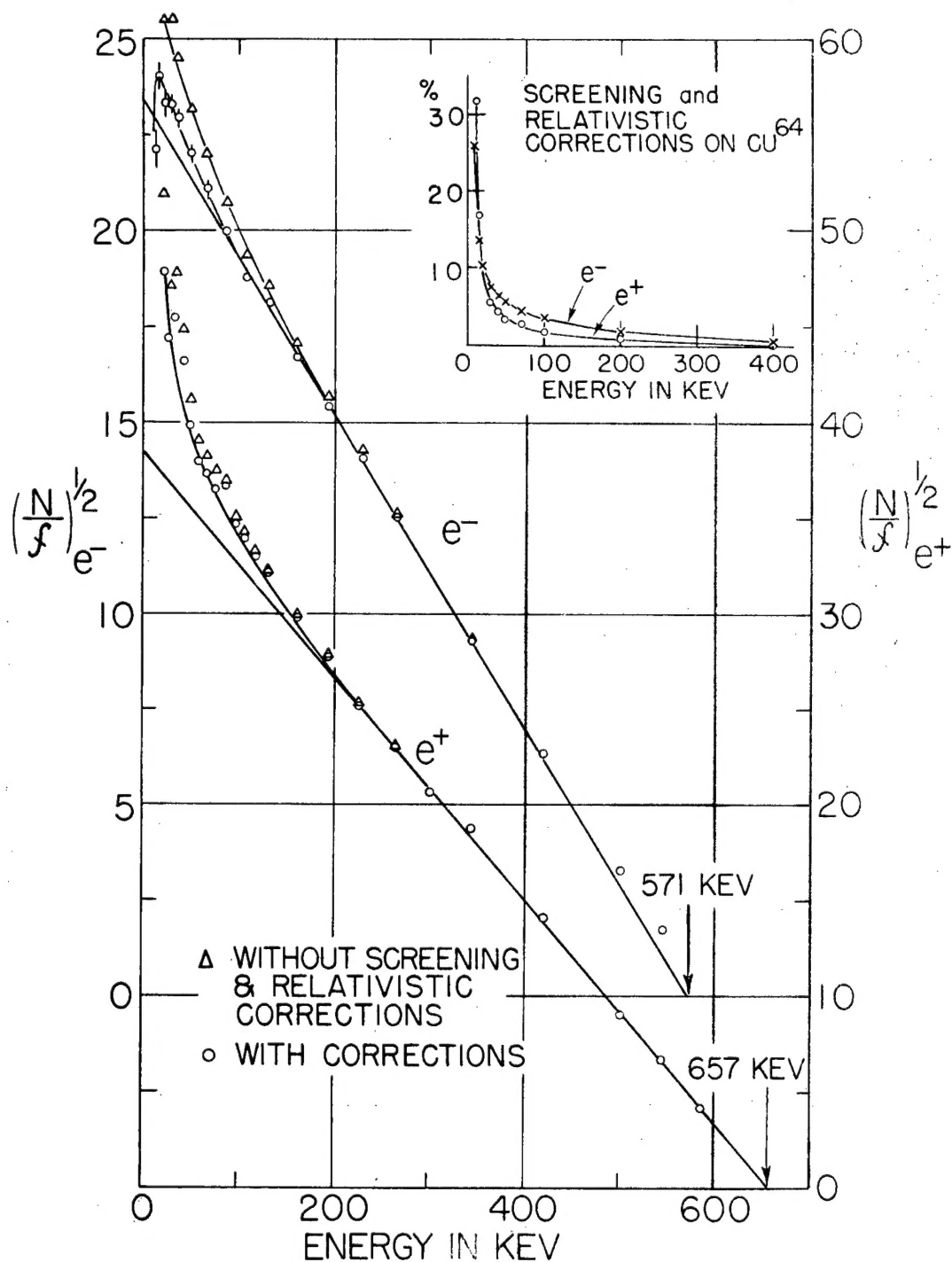


Figure 1. Fermi plots of Cu^{64} negatron and positron spectra.

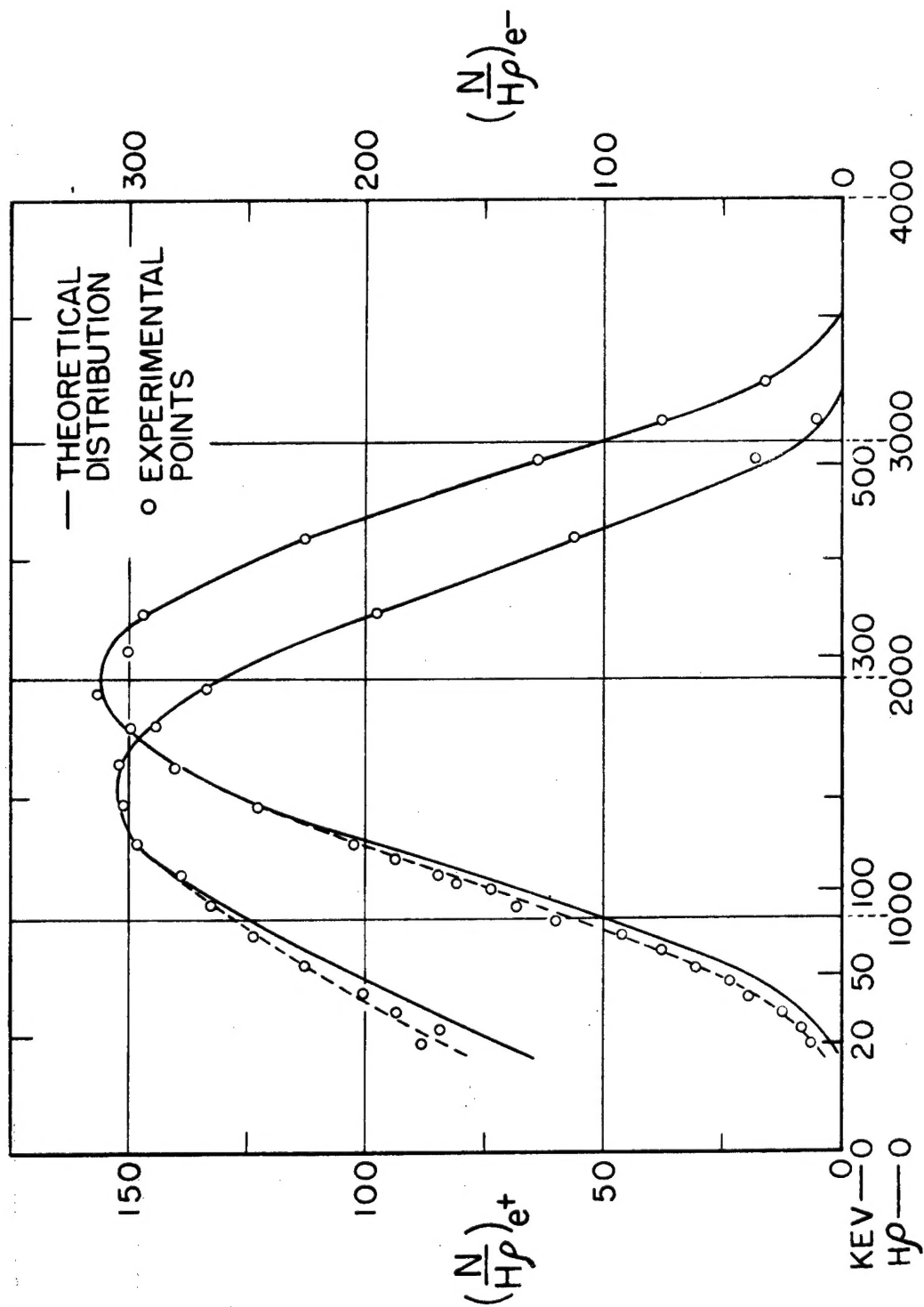


Figure 2. Momentum spectra of ^{64}Cu negatrons and positrons.

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